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STATUS OF LOBSTER STOCKS IN THE NORTHWESTERN HAWAIIAN ISLANDS, 1993

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ABSTRACT

Research trapping indicated that spiny lobster catch-per-unit effort (CPUE) increased slightly from 1992 to 1993 at Maro Reef and Necker Island. Spawning biomass at both areas also increased slightly during the period but remained low compared to earlier years of the fishery. Since spiny lobster population density at Maro Reef remains at critically low levels, fishing at Maro Reef in 1994 will most likely catch slipper lobster which are quickly depleted. A dynamic population model fit to the commercial fishery data from 1983 to 1992 estimated a preliminary 1994 harvest quota of 200,000 lobster (combined catch of spiny and slipper lobsters).

INTRODUCTION

Lobster have been commercially exploited in the Northwestern Hawaiian Islands (NWHI) since the late 1970s. The fishery expanded during 1975-85, and by the mid 1980s as many as 16 vessels were fishing for spiny lobster (*Panulirus marginatus*) and slipper lobster (*Scyllarides squammosus*) in the NWHI. Landings peaked in 1984 and gradually declined during 1985-89. A substantial decrease in lobster landings and catch-per-unit effort (CPUE) was observed 1990, prompting an emergency closure of the fishery. The Crustacean Fishery Management Plan (FMP) was subsequently amended to include an annual 6-month closed season (January-June), annual catch quota, and limited entry program. The annual quota is set at a level that provides an economically viable CPUE (1.0 lobster/trap-haul), while protecting spawning stock biomass from overharvest.

Based on the results of research and commercial test fishing during June-July 1992, the 1992 final quota was set at 438,000 lobster. During the 6-month fishing season 353,212 lobster were caught in 582,801 trap-hauls for an average CPUE of 0.61 lobster/trap-haul. A dynamic population model was used with the 1983-92 commercial data to simulate the response of the lobster population to fishery exploitation. This model indicated that recruitment had dropped at least 50% after 1989 and predicted that the NWHI lobster population would not recover sufficiently to allow a commercial fishery in 1993 (Haight and Polovina 1993). The fishery was subsequently closed for the 1993 season.

This, the ninth annual report on the status of lobster stocks in the NWHI, reports current lobster population research, and attempts to use research and commercial logbook data to forecast changes in the NWHI lobster population in response to various environmental and exploitation scenarios.

RESEARCH AGE-FREQUENCY DATA

Standardized research trapping was conducted from the NOAA ship *Townsend Cromwell* at Maro Reef and Necker Island from June 4 to June 30, 1993. Species composition, length frequency, sexual development, and CPUE data were collected at quadrats standardized temporally, spatially, and by gear type at both locations. Additional exploratory research trapping for juvenile spiny lobster was conducted from small boats in shallow lagoonal areas of Maro Reef. Length frequencies of spiny lobster were converted to age frequencies by applying a growth curve estimated by Polovina and Moffitt (1989). Based on this growth curve, recruitment of spiny lobsters to the fishery occurs at approximately age 3. Age specific CPUE values were calculated by dividing the total number of spiny lobster in each age class by the total number of traps fished at each bank.

Maro Reef

A substantial reduction in research CPUE values of all age classes was first documented at Maro Reef in 1990 (Polovina 1991). This trend persisted through 1993 (Fig. 1). Fishing effort at Maro Reef declined during the latter period in response to the decline in the lobster standing stock. Average fishing effort dropped 64% during the 1990-92 period as compared to average effort during the years 1986-89. Systematic trapping in the shallows of Maro Reef lagoon was performed for the first time during the 1993 research cruise. Four sites, encompassing the span of the reef, were trapped in depths of 1-15 m. The age-specific CPUE distribution from the Maro shallows exhibits fairly uniform distribution. The CPUE values of all shallow age classes were markedly higher than those obtained from outside the lagoon on the commercial fishing grounds (Fig. 2). An interesting aspect of the shallow-water trapping was the discovery of a site which yielded a high percentage of sublegal spiny lobster (Fig. 3), which are typically scarce on the outside of the reef.

Necker Island

At Necker Island, research CPUE values for age-3 lobster dropped substantially from 1988 to 1990, and remained at a reduced level through 1993 (Fig. 4). The CPUE values for age-2 lobster at Necker Island remained relatively stable from 1986 through 1993 and are comparatively higher than the other age class CPUE values. To test whether age-2 sublegal spiny lobster CPUE at Necker Island could be used as a predictor of the abundance of legal lobster in the following year, age-2 spiny CPUE values were compared with average and maximum CPUE values of commercial legal-sized spiny lobster in the following year. Based on the research age specific catch frequency, it was assumed that the age-3 lobster comprised most of the legal-sized commercial catch during the period tested. Both Spearman rank and regressional correlation failed to find a significant relationship between the two variables.

SUBLEGAL SPINY LOBSTER CPUE - MANAGEMENT IMPLICATIONS

Sublegal spiny lobster appear to utilize the same habitat as the adults at Necker Island (Parrish and Polovina, in press). This sympatry increases the probability of sublegal lobster being caught in the commercial fishery. In 1992, sublegal spiny lobster comprised 57% of the total spiny lobster catch at Necker Island. By comparison, sublegal spiny lobster made up only 20% of the total spiny lobster catch at Maro Reef.

Some evidence exists that sublegal lobster may be preyed on by carangids (Gooding 1985) or sharks after release from a fishing vessel. Common thought in Hawaii has been that at a specific bank, a single group of large predators aggregate around a vessel and follow it from trap-string to trap-string, feeding on discarded lobster, eventually becoming satiated. To test this theory, 63 Grey Reef (*Carcharhinus amblyrhyncos*) and Galapagos (*Carcharhinus galapagensis*) sharks were tagged at Necker Island and Maro Reef during lobster trapping operations. Out of 235 sharks counted during trapping operations, only 10 tags were resighted. The majority (9/10) were resighted on the same day of tagging within 1.2 nmi from the tagging location. These tags were resighted on the same trap-line where tagging was performed. Only one resighting occurred after the vessel had moved between trap-lines; this individual was resighted 3 days after tagging, 11 nmi from the tagging location. The above data indicate that while groups of sharks may aggregate around a vessel during trapping operations, they most likely do not follow the vessel from one trapping location to the next around a specific bank. Thus, the pool of potential predators is larger than if a specific group of predators followed the vessel from location to location.

SPAWNING STOCK BIOMASS

Because of the closure of the 1993 fishing season, no data were available to calculate the spawning stock biomass per recruit (SSBR) as required by the FMP. An alternate approach, if research CPUE data are available for a given year, is to calculate an index of spawning stock biomass based on the ratio of the current year's spawning stock biomass (kg/trap-haul) to unexploited spawning stock biomass for the population. The first step in this process is to determine the size at the onset of sexual maturity. A convenient indicator of sexual maturity for female spiny lobster is the size (carapace length [CL]) at the onset of egg production. To determine this size, a hyperbolic tangent function (Tanh) (Polovina 1989) was fit to the proportion of females with eggs. To determine if density-dependent factors might be affecting the spawning biomass, the Tanh function was fit for three periods: 1977-79, 1985-88, and 1990-93. The years of 1977-79 represent a period of light exploitation and high population levels; the years of 1985-88 represent a period of heavy exploitation and a fishing-down of the population. During the years of 1990-93 population numbers declined and density was much less than during the first two periods. At Necker Island the size at onset of egg production dropped significantly from the 1977-79 period to the 1985-88 period and again from the 1985-88 period to the 1990-93 period. At Maro Reef the size at onset of egg production was not statistically different between the 1977-79 and 1985-88 periods, but dropped significantly by the 1990-93 period (Table 1). The 1990-93 CL values obtained from the Tanh function were then used to calculate an index of spawning stock biomass. Spawning biomass at Maro Reef increased slightly from 1992 to 1993 but still remains critically low (Table 2.). Because of the reduced spiny lobster population at Maro Reef, commercial fishing in that area will most likely target slipper lobster. Slipper lobster have made up approximately 45% of the commercial catch at Maro Reef during the last 3 years of fishing. Although initial catch rates of slipper lobster at the beginning of a fishing season can be quite high, slipper lobster at Maro Reef are quickly depleted (Fig. 5). Spawning biomass at Necker Island also increased slightly from 1992 to 1993. Average spawning biomass at both Necker Island and Maro Reef in 1992 was approximately 23% of the pre-exploitation level (Table 2).

1994 COMMERCIAL FISHERY QUOTA METHODOLOGY AND PRELIMINARY QUOTA FORECAST

Commercial fishery data from the NWHI were used in a dynamic population model to investigate recent spiny and slipper population changes (see Haight and Polovina 1993). The model was fit to the pooled commercial CPUE data from 1983 through 1992 (Fig. 6). The resulting parameter estimates were: $R_{(1983-1989)} = 1.675 \times 10^6$ lobster/year, $R_{(>1989)} = 8.38 \times 10^5$ lobster/year, $m = 0.456$/year, $q = 7.32 \times 10^{-7}$/trap-haul. Based on these parameters during the period 1983-89, an estimated 1.67 million lobster recruited to the fishery annually; however, after 1989 the recruitment dropped to approximately 838,000 lobster.

The biological production estimates resulting from the fit of the model were used to determine the number of lobsters which could be taken under present recruitment conditions while allowing the stocks to rebound to a sustainable level and provide an average combined legal spiny and slipper CPUE of 1.0 during the fishing season. The resulting quota equation is as follows:

$$Quota_i = Catch_{(opt)} + [N_i - N_{(opt)}], \tag{3A}$$

where $Quota_i$ = the combined spiny and slipper lobster quota in year i. Based on an annual average CPUE of 1.0, $Catch_{(opt)}$ = 200,000 and $N_{(opt)}$ = 1,420,700. N_i is determined from the equation:

$$N_i = CPUE_i/q, \tag{3B}$$

where q is the population model estimate of catchability, and $CPUE_i$ is the combined legal spiny and slipper catch-per-unit effort during the first month of fishing (July 1994).

To provide a preliminary estimate of the July-December 1994 NWHI commercial lobster quota, the dynamic population model was used to estimate a CPUE value for July 1994 ($CPUE_i$). The estimated $CPUE_i$ value (1.037), was then used in equation 3B, resulting in an N_i value of 1,420,000. The N_i value was used with equation 3A which gave a preliminary 1994 fishing season forecast of approximately 200,000 lobster (90% confidence interval 0-480,000 lobster). A final in-season quota will be determined from Equations (3B) and (3A), where $CPUE_i$ is estimated from a combination of preseason research data and/or commercial logbook data from the first month of fishing.

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Table 1.--Length at onset of egg production for 1977-79, 1985-88 and 1990-93. CL = carapace length (SE in parentheses). *N* denotes sample size.

	1977-79			1985-88			1990-93		
Location	*N*	CL	(SE)	*N*	CL	(SE)	*N*	CL	(SE)
Necker Island	2545	65.5	(0.8)	1568	60.4	(0.9)	2939	50.7	(0.4)
Maro Reef	1534	69.4	(1.4)	2818	69.1	(1.8)	499	51.3	(2.7)

Table 2.--An index of spawning stock biomass (kg/trap-night) for spiny lobster.

	Index by year						
	1977	1988	1990	1991	1992	1993	1993/ 1977
Necker Island	2.45	1.24	0.65	0.65	0.88	0.89	**0.37**
Maro Reef	2.14	1.71	0.36	0.20	0.16	0.17	**0.08**
Mean	2.29	1.48	0.51	0.43	0.52	0.53	**0.23**

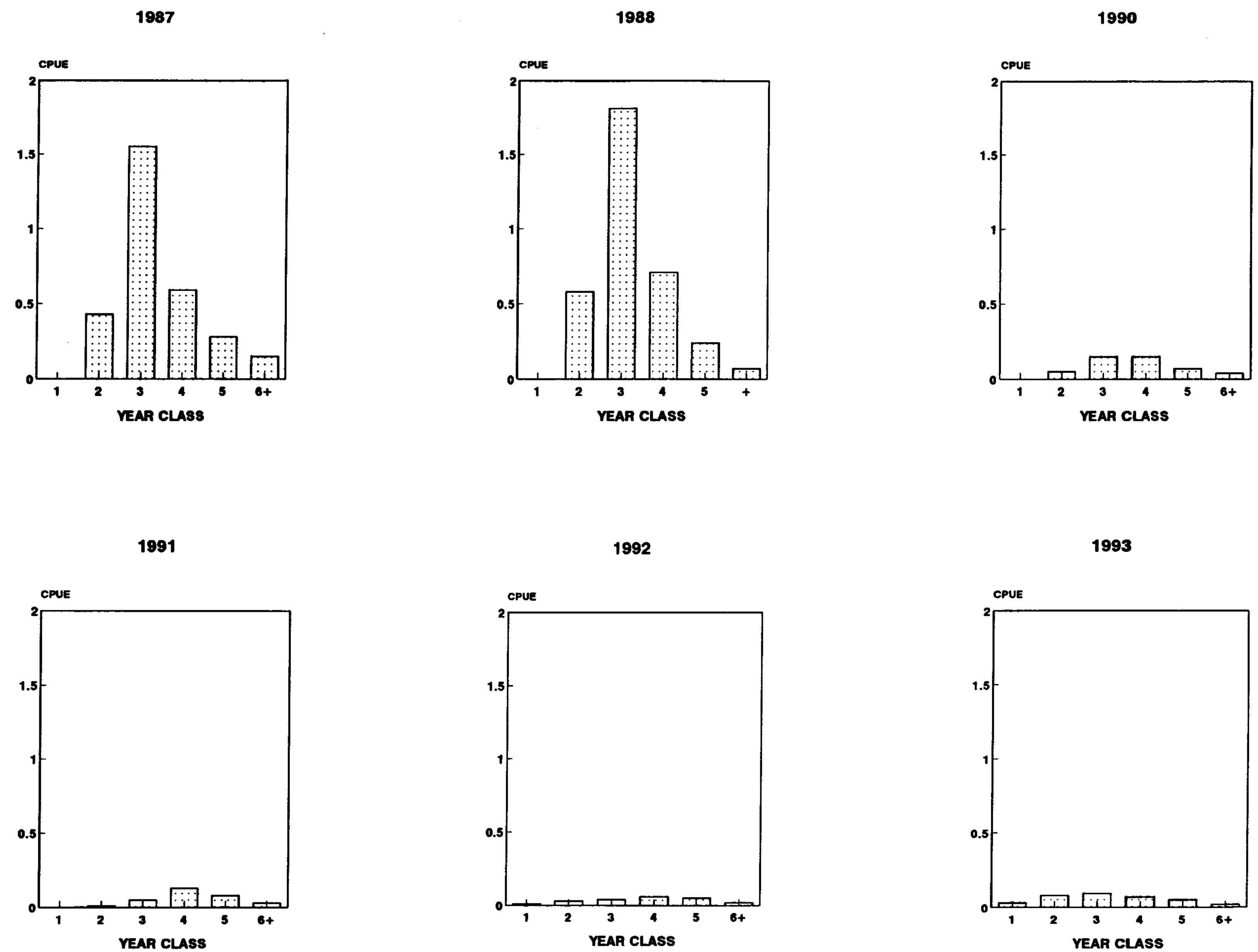

Figure 1.--Catch-per-unit effort for each age class of spiny lobster, Maro Reef, 1987-88, 1990-93.

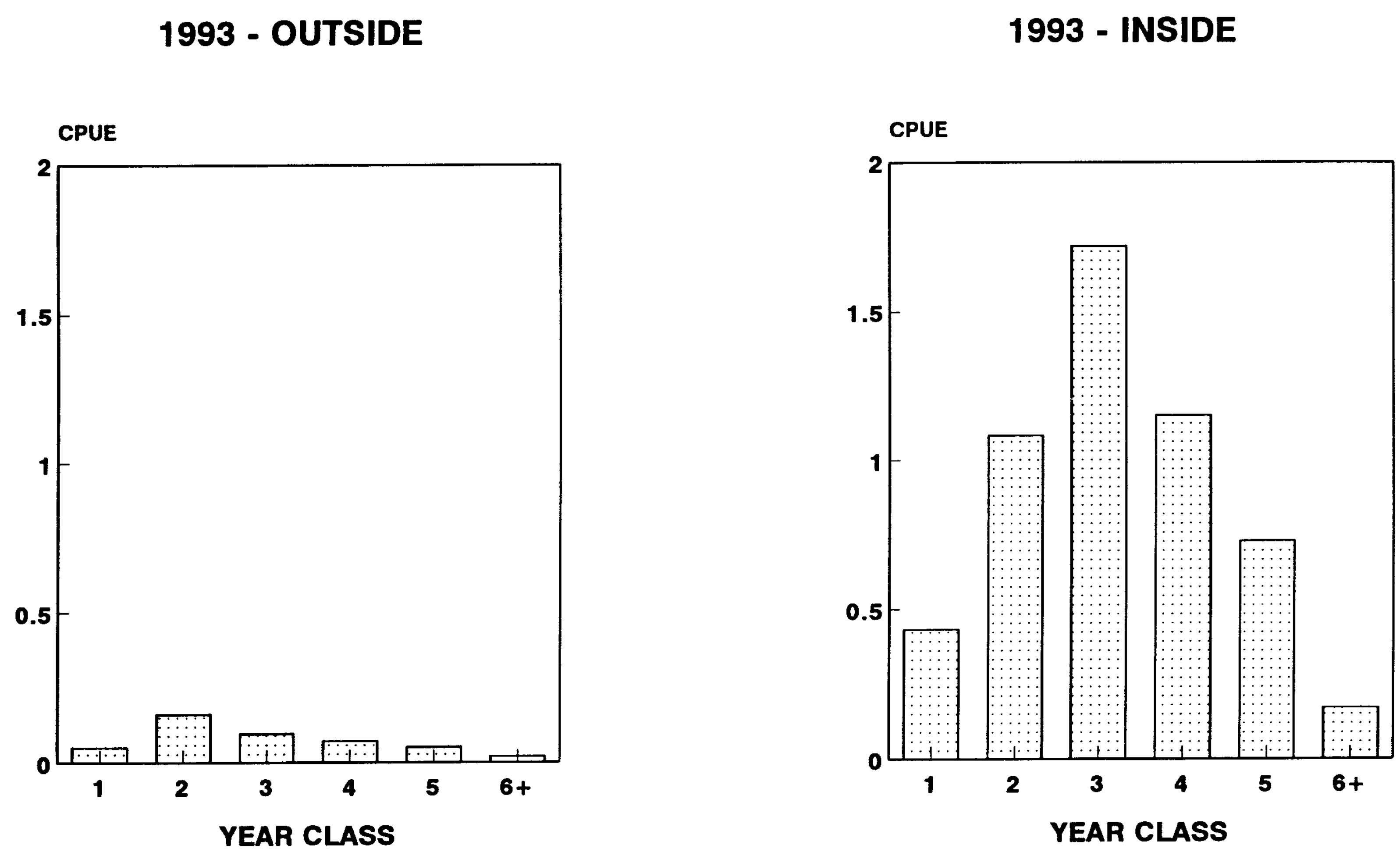

Figure 2.--Catch-per-unit effort for each age class of spiny lobster, inside vs. outside Maro Reef, 1993.

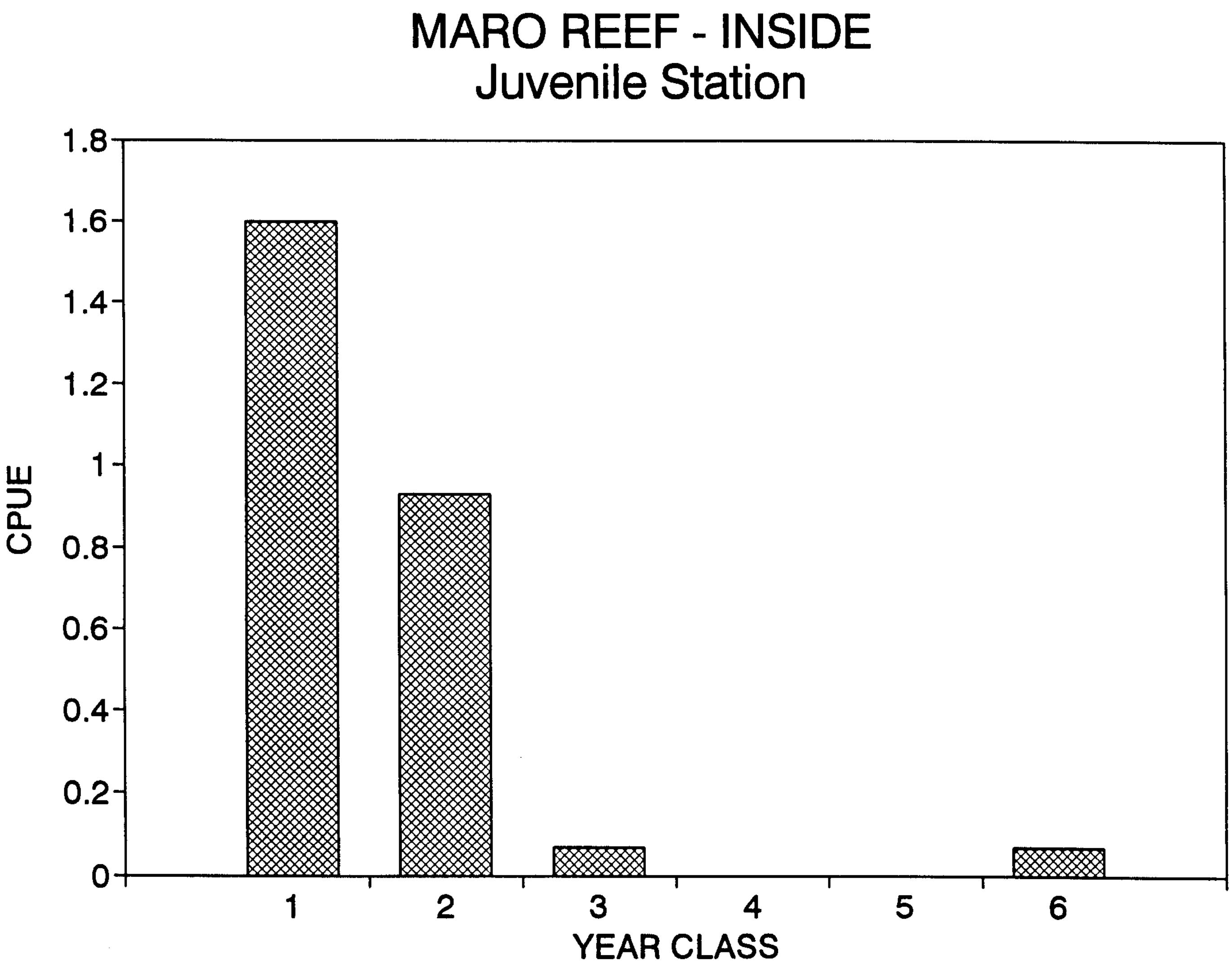

Figure 3.--Catch-per-unit effort for each age class of spiny lobster, Maro Reef, Station 197, 1993.

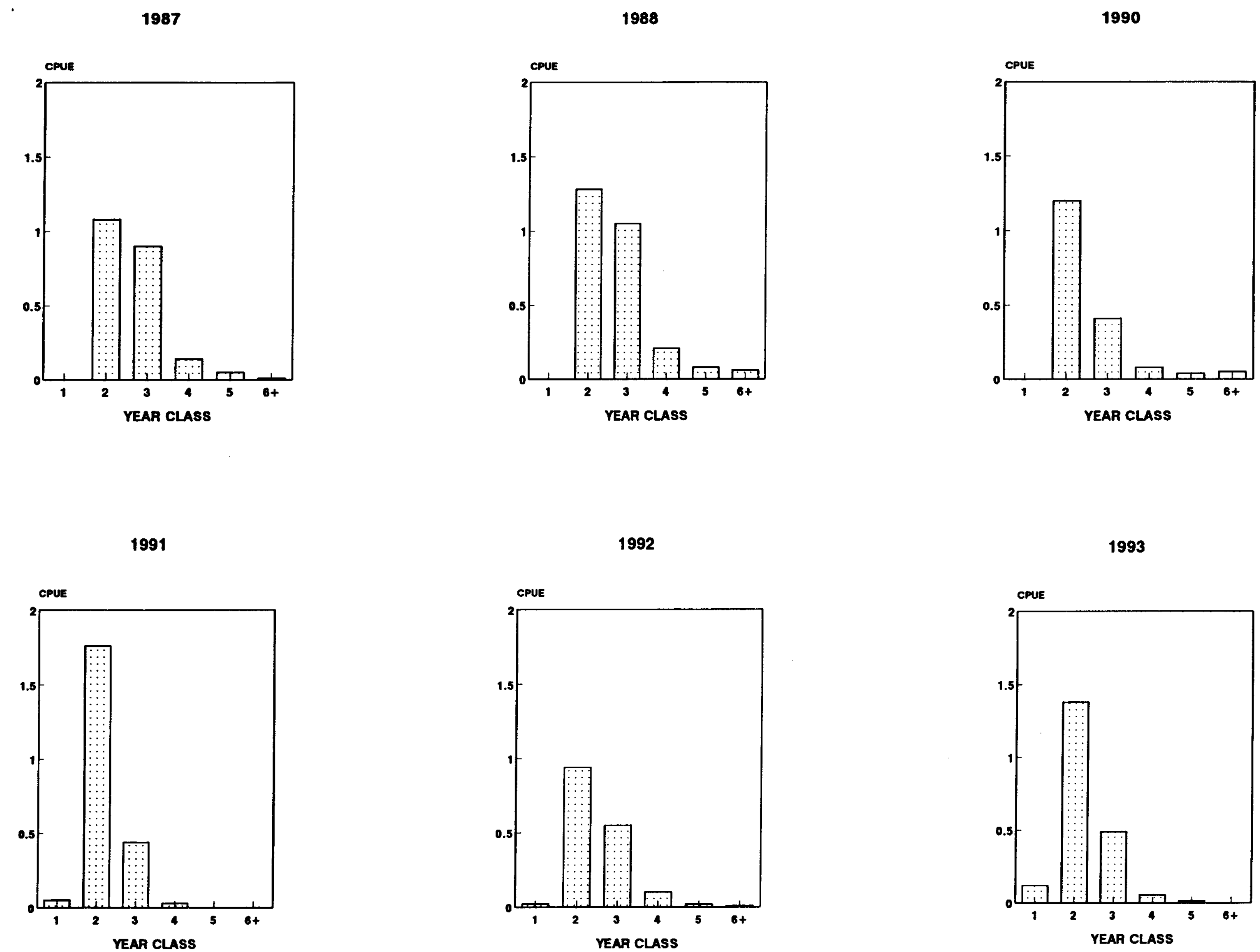

Figure 4.--Catch-per-unit effort for each age class of spiny lobster, Necker Island, 1987-88, 1990-93.

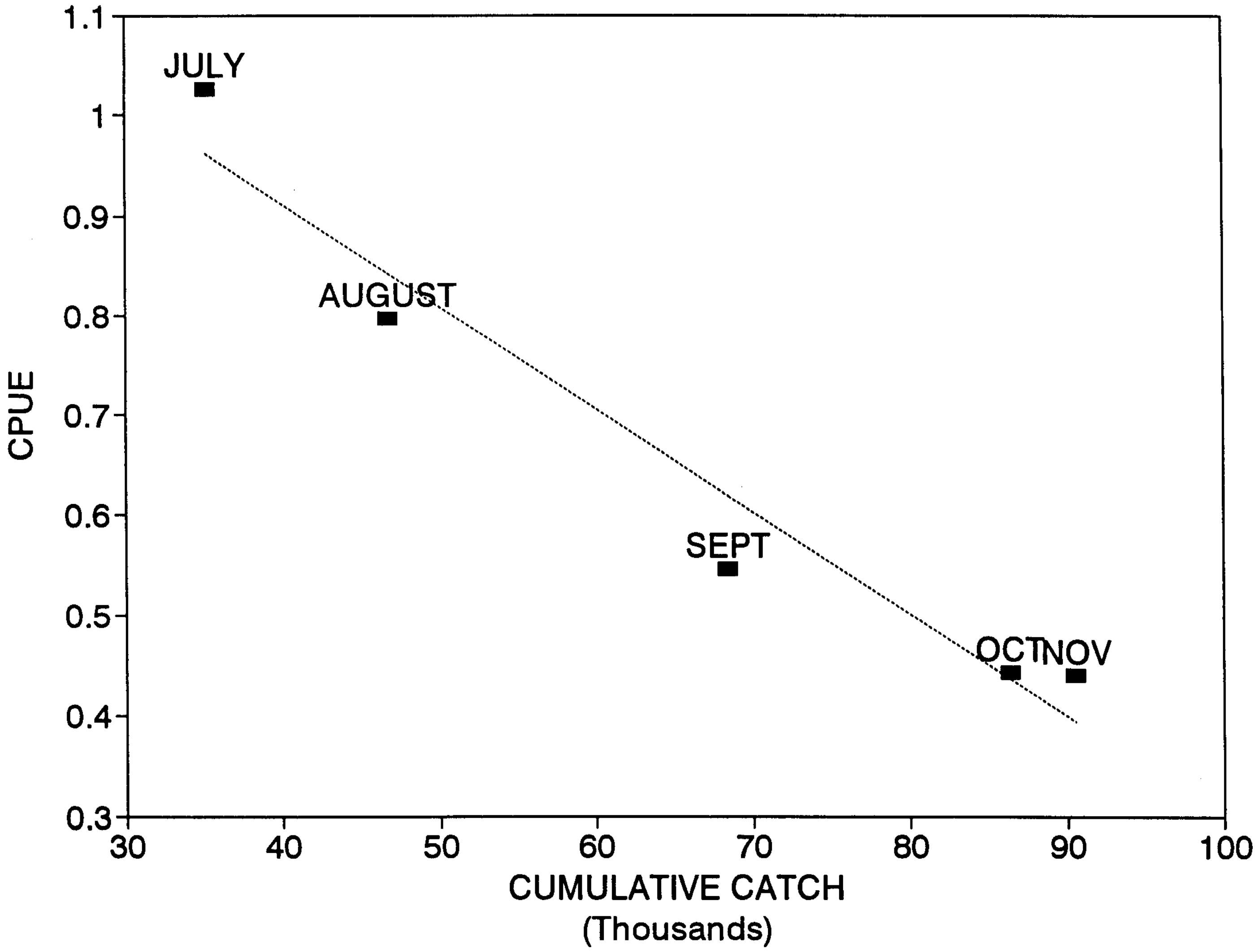

Figure 5.--Slipper lobster catch-per-unit effort vs. cumulative catch at Maro Reef during July-November 1992.

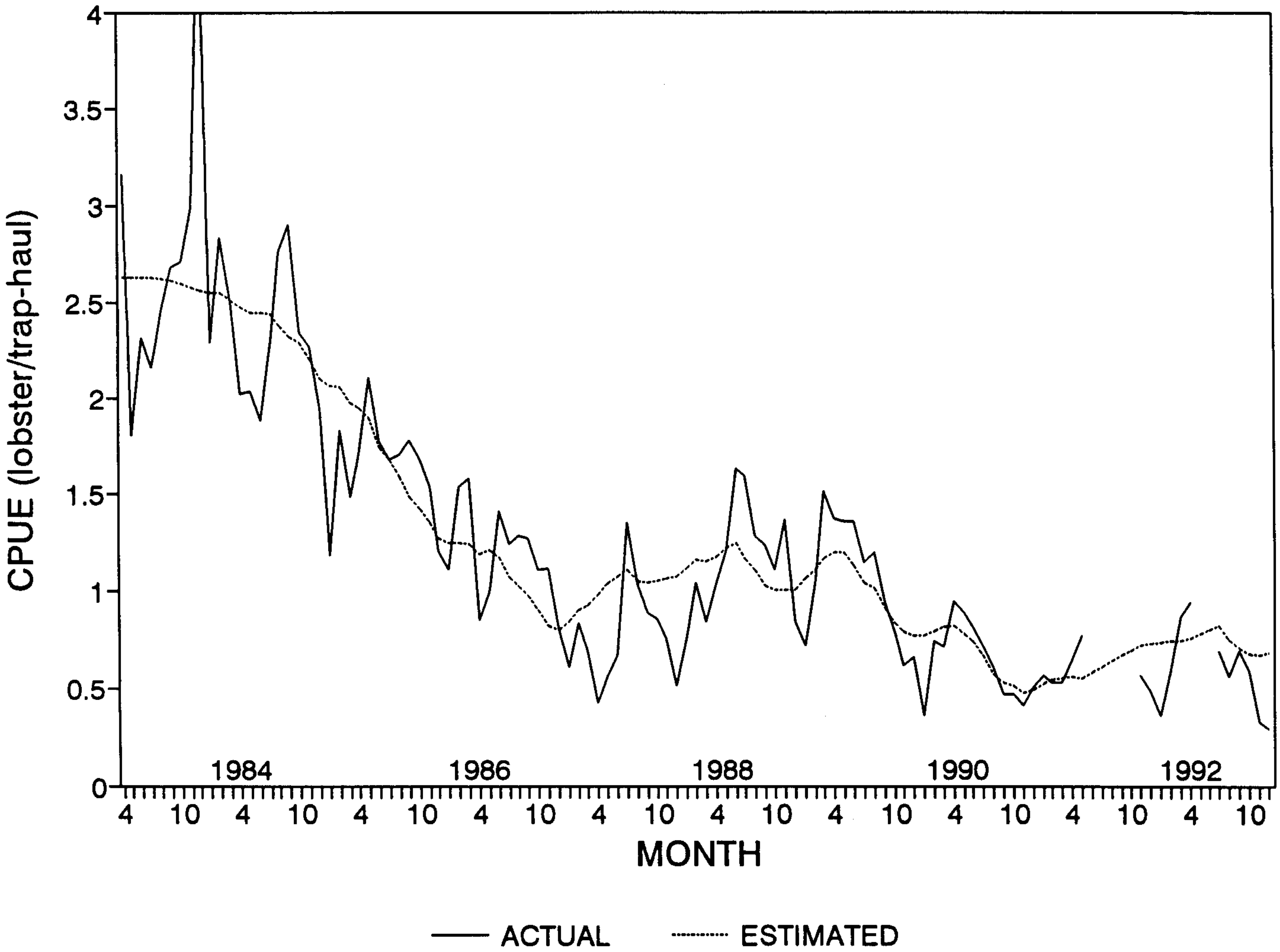

Figure 6.--Monthly catch-per-unit effort (CPUE) and fit of the dynamic population model for spiny and slipper lobsters based on commercial fishery data, 1983-92. After 1989, the estimated CPUE reflects a 50% reduction in model-based recruitment.